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**Original Research Article**

# Early or mild appendicitis on CT imaging and its correlation with a negative appendicectomy: an observational retrospective study

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## ABSTRACT

**Background:** A computerized tomography scan is frequently performed to confirm or exclude appendicitis. The interpretation of such CT scans is crucial in determining which patients should be offered surgery. In a subset of patients with undifferentiated abdominal pain, the radiological diagnosis of "early" or "mild appendicitis" is encountered. It is unclear, based on the current literature, how to manage this entity and hence it may be exposing patients to unnecessary surgery. This raises the question if "early" or "mild appendicitis" on CT imaging correlates with an increased rate of negative appendicectomies.
**Methods:** All laparoscopic appendicectomies from 2018 to 2023 at a single Australian tertiary hospital were reviewed retrospectively for pre-surgical imaging, appendix histopathology, age, gender, and white cell count. The CT early/mild appendicitis group was compared with the CT uncomplicated appendicitis group.
**Results:** Of 599 patients who had uncomplicated appendicitis on CT imaging, 63 of these patients received a diagnosis of early or mild appendicitis. Twenty-two in this group had a normal appendix on histological assessment. The "early" or "mild" appendicitis group had a significantly increased likelihood (OR>10, $p<0.001$) of having a normal appendix on histology, compared to the CT uncomplicated appendicitis group. Women and lower WCC were associated with early appendicitis ($p<0.05$).
**Conclusions:** Results of this study suggest that the diagnosis of "early" or "mild appendicitis" on CT imaging results in a greater number of negative laparoscopic appendicectomies.

**Keywords:** Appendicitis, Laparoscopic appendicectomy, Mild, Early, CT

## INTRODUCTION

In patients with acute abdominal pain who present to the emergency department, computerized tomography (CT) imaging is increasingly being performed to confirm and/or exclude a range of diagnoses, with appendicitis being of high importance.[1] This is especially true when the patient is stable with an equivocal history and clinical examination, supported by non-diagnostic haematological and/or biochemical results. As appendicitis remains primarily a clinical diagnosis, imaging is of importance when the clinical picture is unclear. Appendicitis has a global incidence of 0.2% per year, with a lifetime risk of approximately 7%, and has been increasing steadily over the last several decades.[2] Despite ongoing research into the suitability of antibiotics as the sole management for appendicitis, surgery remains the cornerstone of treatment.[3,4] Consequently, the intention of imaging is to dictate whether the patient should have an operation and therefore the CT scan has the potential to circumvent the need for invasive treatment. Medicolegal pressures to provide a diagnosis, with minimal doubt, also have

increased the number of tests required to confirm a diagnosis, with the CT scan being no exception.[5,6] Fortunately, the availability of CT imaging has increased markedly over the past decade, allowing patients who present with abdominal pain to be investigated with imaging.[7] Australia has 59.6 CT scanners per million people, ranking high globally, especially considering the availability of free or subsidised scans.[7,8] Patients with ambiguous clinical features of appendicitis who undergo CT studies, can be streamlined through the health service based on their radiological diagnosis. If no pathology can be found they can be discharged home, with education of signs and symptoms for representation. Moreover, if an alternate pathology to appendicitis is discovered, they can be referred to the appropriate unit. If a diagnosis of appendicitis is made, they can proceed to a laparoscopic appendicectomy with minimal delay and a high certainty of the diagnosis.

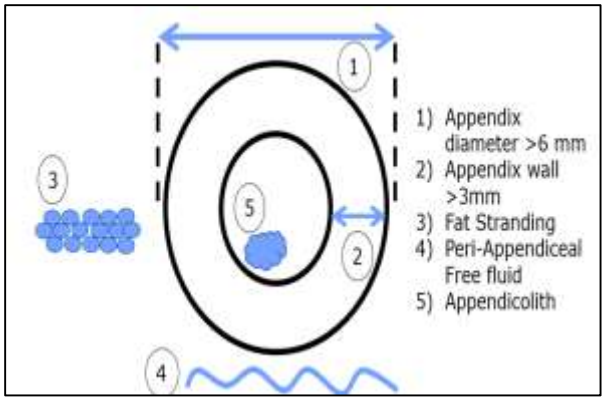


**Figure 1: Radiological features to support acute appendicitis (simplified axial view of appendix lumen).**

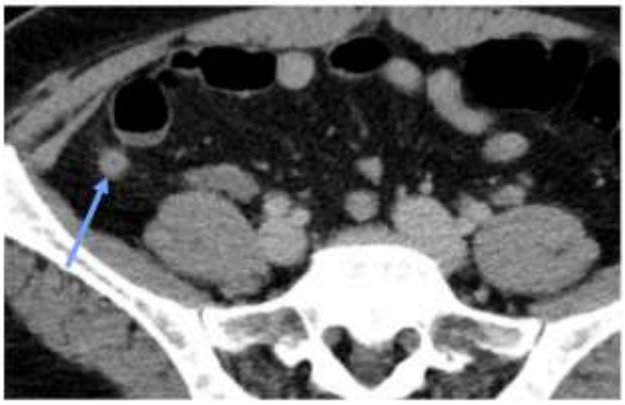

**Figure 2: Axial CT with venous contrast showing a 5mm appendix (blue arrow) with minor fat stranding, reported as early appendicitis.**

Stable patients with lower abdominal pain, with a radiological diagnosis of 'early' or 'mild' appendicitis present a challenging subset of patients to manage. This term has paradoxically made the decision to treat or observe, more difficult, as it is not represented in the literature. The radiological standard for the diagnosis of appendicitis is variable, and differs from centre to centre, like the varying array of clinical scoring systems (such as Alvarado's Score).[9] A cluster of radiological criteria are required when diagnosing appendicitis, as shown in (Figure 1).[10,11] CT imaging using these constellations of measures has a reported sensitivity of ~95% and a specificity of ~97% for diagnosing appendicitis as a dichotomous outcome; that is, acute appendicitis or a normal appendix. By incorporating terms such as 'early' or 'mild' appendicitis, the cut off values for diagnosis will be altered, and hence test characteristics will change. An anticipated increased sensitivity will be achieved at the expense of specificity, however there are no studies on this specific radiological entity and its effect on the test characteristics of CT imaging. These considerations in the current health climate have led to the primary objective: does "early" or "mild appendicitis" on CT imaging lead to an increase in negative appendicectomy rates?

## METHODS

Patients who underwent a laparoscopic appendicectomy from April 2018 to April 2023 at a single Australian tertiary hospital (Royal Brisbane and Women's Hospital) were analysed via an observational retrospective cohort study. The (Figure 3) outlines the process of the study population selection. Retrieval of data was via International classification of diseases tenth edition (ICD-10) procedural codes, using the hospitals internal surgical records system.[12]

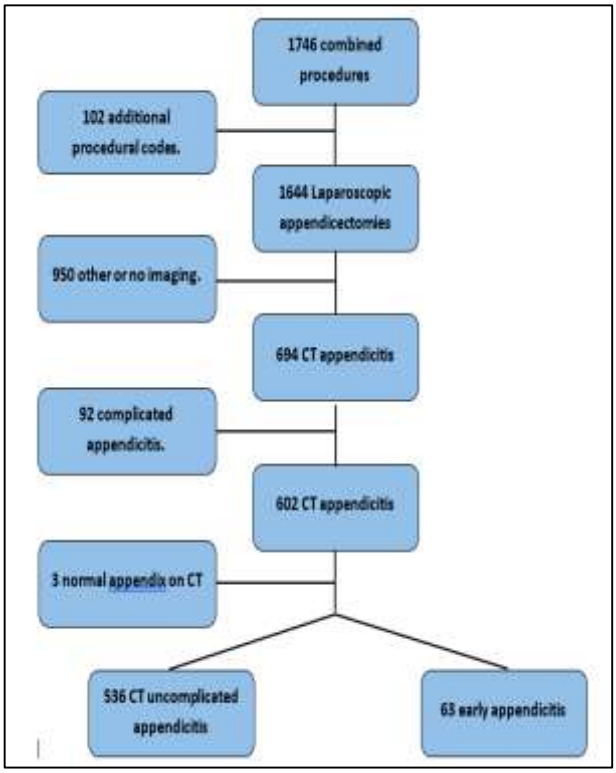


**Figure 3: Process of study group selection.**

An alpha of 0.05 and beta of 0.2 was set for our study for the threshold for type I and type II errors. We searched for the procedural code 30572-00, designated to the laparoscopic appendicectomy procedure.

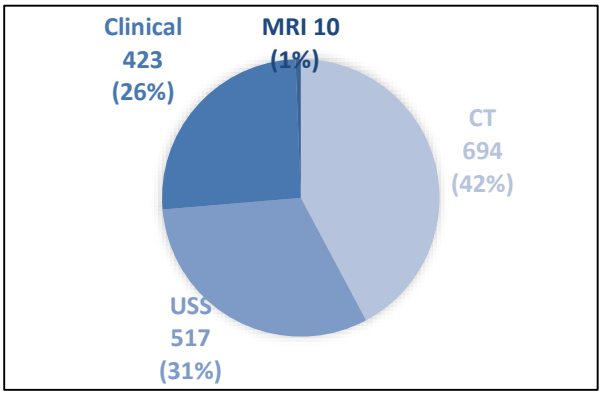


**Figure 4: Diagnostic imaging used prior to laparoscopic appendicectomy.**

Total 1746 patients had a surgical procedure over the 5-year period pertaining to the ICD code for a laparoscopic appendicectomy. Patients with concurrent procedures performed during the appendicectomy (such as a colectomy), were removed from analysis, resulting in 102 patients being excluded. The remaining 1644 patients were analysed to determine the imaging received prior to the operation. Retrieval of imaging was via the hospital systems patient database software. Any patients without imaging had their admission and operative notes reviewed, to ensure community imaging was not performed. The results of the 1644 patients and their pre-operative imaging are displayed in (Figure 4). 694 had a CT scan, 517 had an abdominal and/or pelvic ultrasonographic study (USS), 10 had a magnetic resonance (MRI) study and 423 were clinically diagnosed. Of the 694 CT appendicitis patients, 42 had an initial USS.

The imaging reports of the 694 patients with a CT diagnosis of appendicitis were reviewed. All patients had a report produced by a specialist radiologist. Patients who were reported as having complicated (perforated or phlegmons) or a suspicion of complicated appendicitis, were removed from further analysis, which accounted for 92 patients being excluded. Of the remaining 602 patients, imaging reports with the specific term "early appendicitis" or "mild appendicitis" were placed into the early-appendicitis (EA) group. Patients with other terms such as 'likely', 'suspicious', 'equivocal' were not included in the early appendicitis group. 63 patients had early, or mild appendicitis diagnosed on their CT imaging report. 536 had uncomplicated appendicitis (UA) and would serve as the comparison. Three imaging reports stated that a normal appendix was present, and these were excluded from the study population. The histopathological results of the 536 UA group and the 63 EA group were reviewed. All patients had appendix histopathology performed at this health institution and therefore no patients were excluded during this process. The histopathology was completed by a pathology specialist and recorded on the hospital's pathology records system. The ratio of negative appendicectomies, based on the histopathological diagnosis of appendicitis being the gold standard test, was determined for each study group. Secondary factors of age, gender and WCC were also retrieved during the data collection process. We utilised a Chi-square test for categorical variables and a t test for continuous variables. All patients included for analysis were contacted via phone for consent to use de-identified treatment and demographic data for publishing.

## RESULTS

The EA group had a normal appendix on histology in 22 of the 63 patients, equating to 34.9% of the group. The UA group had 26 normal appendixes in the group of 536, translating to 4.9% of the group. A Chi-square test was performed to examine the correlation between the early/mild CT diagnosis and having a normal appendix on histology. The relation between these variables is significant, $\chi^2$=69.15, p≤0.001, demonstrating that early appendicitis is more likely to result in a normal appendix on histopathology. The odds ratio of the EA to UA group is 10.2 (CI=5.49 to 20.18) (p<0.001). The (Table 1) displays the group characteristics measured.

**Table 1: Group characteristics.**

| Data | CT early appendicitis | CT uncomplicated appendicitis | EA group compared to UA group |
|---|---|---|---|
| **Total number** | 63 | 536 | N/A |
| **Appendicitis on histopathology** | 41 | 510 | |
| **Normal appendix on histopathology** | 22 | 26 | |
| **Prevalence of a normal appendix N (%)** | 0.349 (34.9) | 0.0485 (4.9) | OR 10.2 (5.49-20.18), p<0.001 |
| **Female** | 39 | 248 | N/A |
| **Male** | 24 | 288 | |
| **Prevalence of females in the group N (%)** | 0.619 (61.9) | 0.462 (46.2) | OR 1.88 (1.10 to 3.23), p=0.02 |
| **Mean age (years)** | 31.4 (σ 5.2) | 34.1 (σ 2.1) | p=0.003 |
| **Mean WCC (x10$^9$/l)** | 8.9 (σ 1.1) | 10.4 (σ 1.2) | p=0.04 |

The EA group were younger, (p=0.003) had a lower WCC count (p=0.04) and more likely to be female (p=0.003) when compared to the uncomplicated appendicitis group. The age characteristics of each group are shown in (Figure 5-6).

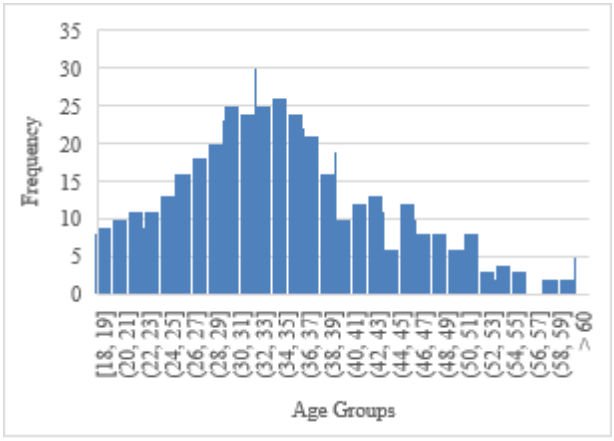


**Figure 5: Uncomplicated appendicitis age distribution.**

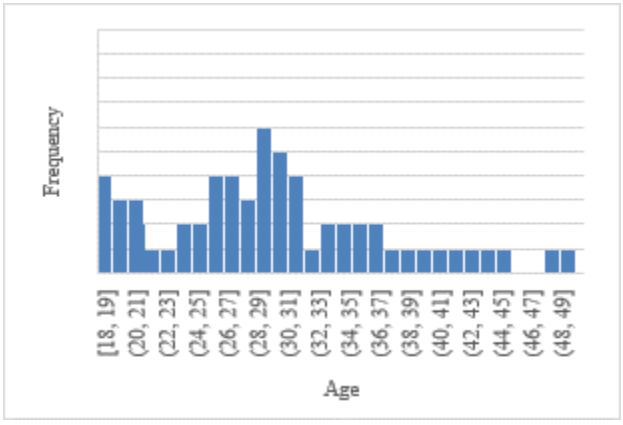


**Figure 6: Early appendicitis age distribution.**

The yearly rates at which early appendicitis was reported is displayed in (Table 2). An increasing amount of early appendicitis, proportional to the number of CT scans prior to a laparoscopic appendicectomy, was demonstrated consistently each year.

## DISCUSSION

The importance of subjective terminology and using terms such as 'early' or 'mild' for dichotomous pathologies are raised by this study, demonstrating the potential for it to significantly impact on a patient's treatment. The rate of negative appendicectomies in our early appendicitis group was significantly higher than the described Australian negative appendicectomy rate of ~21-24%, when accounting for all methods of diagnosis.[13] Given the high rate of mortality with untreated appendicitis, this proportion of negative appendicectomies is deemed acceptable and is consistent globally.[14] One third of patients in the early appendicitis group in this study population would be anticipated to be appropriate for conservative, non-surgical management. Deciding which of these early appendicitis patients who should not proceed to appendicectomy is an area for future research.

Two-thirds of the CT early appendicitis population had histopathological evidence of inflammation, with a non-significant WCC and hence the diagnosis of early or mild appendicitis still warrants diligence. A standard approach in patients with equivocal signs of appendicitis, with haemodynamic and clinical stability, is observation with serial vital sign measurements, abdominal examinations, and repeat blood work to assess for trends in WCC. This usually occurs over a 12–24-hour period. Antibiotic treatment is not administered in these patients to ensure improvement of their symptoms was not attributed to other factors. We raise the opinion that early appendicitis could be safely managed in a similar manner, with a period of observation. A difficulty surrounding this observation period may arise if the patient views this as delaying treatment, as a label has been attached to their symptoms. Diagnostic labelling may also cause patients to experience anxiety and be much more aware of their pain until an operation is performed.[15]

**Table 2: CT scans and early appendicitis diagnosis over the study period.**

| Year (commencing from April) | CT scans (including complicated appendicitis) | Proportion of females (%) | Early Appendicitis CT |
|---|---|---|---|
| **2018** | 117 | 39 | 6 |
| **2019** | 123 | 40 | 7 |
| **2020** | 132 | 41 | 9 |
| **2021** | 156 | 44 | 19 |
| **2022** | 166 | 46 | 22 |

Operating on a patient, who's pain is not attributed to the CT diagnosis of early appendicitis, is reasonably foreseen to have poor outcomes. A laparoscopic procedure is associated with pain and reduced functioning post procedure. If a patient's cause of pain or symptoms are not treated by the operation, it can be anticipated that these will be no better or indeed worse post-operatively, since the true pathology has not been ameliorated. Patients in our study group were not followed up post-operatively to determine if an alternative diagnosis was made for their pain given that all patients had a laparoscopic appendicectomy based on that being the

most likely diagnosis. This, however, is an area we intend to review in the future. If the decision is to operate on a patient with early appendicitis; the economic, health workflow and intangible implications must be considered. The cost of an appendicectomy admission is substantially higher than general admissions, with operating theatres and anaesthesia related expenses contributing to greater than 50% of the total cost.[16] The minor complication rate of a laparoscopic appendicectomy is ~9.4% in Australia, mostly represented by surgical site infections and readmissions for monitoring, which also must be considered.[17] The post-operative recovery period in which the patient may not be able to perform employment or meaningful activities, can cause a degree of unmeasurable burden and this period may range from 2-6 weeks depending on the surgical teams advice.[18,19] The true prevalence of early appendicitis is difficult to interpret. The number of patients with a CT scan showing early appendicitis that were not referred from the emergency department for surgical management, is not known. Furthermore, as histopathology is required for a definitive diagnosis of appendicitis, only those who receive an operation can be evaluated if they have definitively had appendicitis or not. Importantly, patients without an index of suspicion for an appendiceal pathology would not proceed to operation, as the diagnosis is primarily clinical. Therefore, we suspect that the prevalence of CT early or mild appendicitis is more prominent in the general population than in our dedicated study population.

CT is used more frequently when diagnostic uncertainty exists. This is particularly true in younger patients where the use of ionising radiation can be avoided if there is a clear clinical picture. As such, the proportion of patients in this observational study with a CT diagnosis of early appendicitis may be higher than that expected in all patients presenting with right iliac fossa pain since all included patients underwent a CT of the abdomen and pelvis. There is a trend of increasing CT scans, particularly in females over the past 5 years which should also raise concerns, given the stochastic of imaging and impact on future fertility.[20,21] As females were associated with early appendicitis, this raises theories as to why they are overrepresented. A potential reason, referring to (Figure 1), is the potential for ancillary signs of appendicitis to be shared by other gynaecological pathologies, such as peri-appendiceal free fluid.

### *Limitations*

Several limitations exist, the most important being that this is a single centre observational study. Although radiologists rotate through this centre, there may be an institutional bias and hence a multi-centre study would be valuable. This hospital is representative of tertiary centres throughout Australia, however extrapolation to other continents may not be appropriate due to different diagnostic practices for appendicitis. The population size is adequate, however given the small percentage of early appendicitis patients, retrieving data at another centre during the same period would aid in further demonstrating the impact of early appendicitis. Analysis of all patients presenting to the emergency department with early appendicitis was not performed due to resourcing issues, however it would provide valuable insights into the amount of early appendicitis patients that do not proceed to the operating theatre. Follow up of early appendicitis patients with negative appendicectomies would provide useful data into the patient's symptom resolution, particularly in the long term with respect to representation rates.

## CONCLUSION

This study serves to raise awareness of an emerging radiological term of 'early/mild' appendicitis, that pose a management dilemma to all clinicians undertaking emergency general surgery. These patients, presenting with equivocal features for appendicitis, may receive a diagnosis of early or mild appendicitis on a CT study. This label should be approached with a degree of caution. If the decision is made to perform a laparoscopic appendicectomy, patients ought to be informed on the potentially higher probability of having a normal appendix and that their symptoms may not be alleviated by the procedure. Those diagnosed with early appendicitis may reasonably have an observation period, and proceed to operation if any of their clinical condition or serial investigations worsen. The radiological criterion for appendicitis is not uniform and consideration of the complete clinical picture is paramount. Additional research is required for more robust evidence on the management of early or mild appendicitis and to determine its prevalence across multiple centres.

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*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee*

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